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Facilitative transfer in prose learning of elementary school children.

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FACILITATIVE TRANSFER IN PROSE LEARNING
OF ELEMENTARY SCHOOL CHILDREN

A Thesis Presented

by

Marcy R. Perkins

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"There is perhaps no more important topic in the psychology of learning than transfer of learning," according to Ellis (1965, p.5). The import of this statement becomes clear when one considers how much an individual's performance on particular tasks is influenced by his previous learning history, or, indeed, how difficult it is "to think of any adult learning that could not be affected by earlier learning. We might, in fact, regard all studies of learning beyond a very early age as studies of transfer of learning" (Ellis, 1965, p.5). Examples of transfer of learning in all kinds of situations are numerous. A music student who plays the flute competently, for instance, will have little trouble learning to play the piccolo, with its nearly identical note fingerings. Or, on the other hand, a citizen of England or Japan, where it is the custom to drive on the left side of the street, may have difficulty in remembering to look left instead of right when crossing the street in America, an action which could have dire consequences! Transfer of learning simply means, then, that one's experience or performance on some task influences his performance on some subsequent task, and this influence can be either of a facilitating or an interfering nature, such that experience on the first task can aid or inhibit performance on the second one. This simple transfer is usually measured experimentally in terms of the following paradigm:

Experimental group (E):	Learn Task A	Learn Task B
Control group (C):	---	Learn Task B

In comparing the performance of subjects in both groups on Task B, subjects in E should perform at a higher level than those in C if the influence of learning Task A was facilitory, but they should perform worse than those in C if the influence of learning Task A was interfering.

One step beyond the simple transfer design described above are designs used for measuring proactive or retroactive transfer, and these involve some kind of retention measure. In other words, what is being measured is the influence of the learning of one task on the retention of another. Proactive transfer refers to the influence of previous learning on the retention of later learning, which is essentially the same as the simple transfer paradigm with the addition of a retention measure of the second task. Retroactive transfer is the influence of later learning on the retention of earlier learning, as illustrated by the following experimental design:

E:	Learn A	Learn B	Test A
C:	Learn A	---	Test A

And in both designs, the transfer that occurs can be either facilitory or interfering.

Since nearly all adult learning can be viewed in terms of a transfer model, it is no surprise that many educational programs are based on the assumption that what is taught in the classroom or training program will transfer to new situations. Doctors learning surgical techniques, for example, must be able to transfer their learning from books, pictures, and dummies to living, breathing, human beings. The problem for education, then, becomes that of identifying the conditions

or variables that affect transfer--actually how transfer occurs--and further, putting this knowledge to use in designing curricula that will maximize facilitatory transfer and minimize negative transfer.

Rote vs. Meaningful Learning

Early research in memory, i.e., studies involving retention measures, utilized the transfer paradigm to establish interference theory (represented by negative transfer) as a viable theory of forgetting. The variables identified as influencing the amount of forgetting, or amount of interference, are the amount of training on the original task, the amount of interfering material, and the degree of similarity between the stimuli and required responses of the two. But "the laws of forgetting are based largely on research with nonsense syllables and lists of discrete words. An important question therefore is whether these laws also apply to memory for meaningful material..." (Anderson & Faust, 1973, p.451). It must be the case that they do in order for the research to be of any worth to educators.

Interference Theory and Prose Learning (See Cunningham, 1972, and Anderson & Bower, 1973, for more extensive reviews.)

Slamecka (1959, 1960) was among the first to begin investigating the possibilities of generalizing principles of interference theory to prose learning. Subjects in his experiments read an original prose passage, one or more than one interpolated prose passages, and were then tested on the original passage. Slamecka's results using connected discourse closely matched those obtained with paired associates, thus in-

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interpolated learning interfered with the retention of original learning. However, some investigators have argued that his methodology forced rote learning (e.g., Anderson & Myrow, 1971). Passages were presented word by word on a memory drum by the serial anticipation method, and subjects were encouraged to recall verbatim. Since school learning generally calls for comprehension and gist recall, Slamecka's studies did not approximate meaningful learning conditions.

Entwistle and Huggins (1964) more closely approximated a meaningful learning situation by performing their experiment in the context of a college classroom. After an introductory lecture given to all subjects, experimental subjects studied a passage on voltage principles, followed by a passage on current principles, and were tested on voltage principles. They performed worse on the test than a control group of subjects who studied the same passage on voltage principles, followed by an irrelevant passage on computer programming. These results support retroactive interference (RI) as applicable to meaningful learning. Another study by the same authors designed to investigate proactive interference (PI) showed that it, too, occurred in this situation.

Anderson & Myrow (1971) and Myrow & Anderson (1972) argued that to reliably find RI in prose, the specifications of the interference model must be closely approximated, such that the retention measure must be sensitive to the specific similarities and differences between the original learning passages. Test questions, in other words, must be employed that would be answered differently on the basis of the similar but con-

flicting information contained in the two passages, since only these questions would be expected to show interference. Questions which could be answered correctly on the basis of either passage would be expected to show facilitation, and questions testing information contained in the original passage that was unrelated to information in the interpolated passage should show no effect. Not surprisingly, their results reaffirmed that RI can occur with realistic prose materials. Their evidence also suggested that most of the RI that occurred could be attributed to specific sources of transfer. There was little reason to believe that nonspecific transfer was a major factor, although, as will be seen later, nonspecific transfer is of greater interest and relevance to educators.

Two studies which extended previous findings were Crouse (1971), who demonstrated that an increase in similarity between original and interpolated learning passages results in an increase in RI, and Kalbaugh and Walls (1973), who showed that PI and RI increase as the number of interpolated passages increases. A significant factor in the latter experiment is that it was done with eighth grade children with results comparable to studies done with adults. Also, since performance of subjects in the RI group was consistently lower than those in the PI group, Kalbaugh and Walls suggest that cueing may be used to facilitate performance by providing additional experience and nonspecific transfer training to broaden the learner's contact with appropriate response settings.

A recent study by Bower (1974) demonstrated both interference and facilitation of retention of prose materials. The

"conceptual macrostructures" of the original and interpolated learning passages were similar, so that retention of main conceptual categories and relations was facilitated. Retention of specific details, or "microstructure," however, was inhibited, since these details differed between passages. Though his methods encourage rote recall, Bower argues that subjects will establish associations between semantic concepts whether they are required to read for comprehension and gist recall or whether they are required to read for serial, verbatim recall. According to Bower, then, his results using methods encouraging rote recall should not be significantly different from results of other methods that could have been used. And, as was the case in previous studies, the interference and facilitation shown were a function of specific transfer sources.

Facilitory Transfer: Ausubel's Theory of Subsumption

David Ausubel and his associates are notable in their failure to find retroactive interference. Instead, their subjects showed a slight facilitation of retention of the original passage after exposure to a similar interpolated passage, which led them to postulate that the interpolated passage increases or decreases the discriminability of the original passage from its anchoring concepts in cognitive structure (Ausubel, Robbins & Blake, 1957; Ausubel, Stager & Gaite, 1968). This hypothesis is based upon Ausubel's (1963) subsumption theory of meaningful learning, which proposes that potentially meaningful information is subsumed under a relevant and inclusive conceptual system. In other words, the individual's prior knowledge--existing cognitive structures--in any particular

subject field is the primary factor influencing learning and retention of new information in that field. "Probably one difference between a novice and an expert in a subject matter is the ease and reliability with which an expert can supply a rich elaboration of a context for any new assertion regarding familiar concepts in his field of expertise" (Bower, 1974, p.8). In the above two studies, then, the similar material of the interpolated passage could have served to enrich and strengthen the already existing cognitive structures related to the original passage, making that information more discriminable and memorable. Ausubel et al (1957, 1968) did not, however, consider in detail the similarities between the original and interpolated learning passages, nor were their recall test procedures sensitive to these similarities, so that their findings of some facilitative effects are somewhat questionable (cf. Anderson & Myrow, 1971).

Although the results of Ausubel's studies may be invalid, his subsumption theory is appealing. From the standpoint of education, it makes more sense to be concerned with the problem of how retention is facilitated, not how forgetting is induced (e.g., interference theory). A further implication of the theory is that any student who experiences difficulty in learning new academic materials is cognitively unprepared to comprehend those materials, so that it becomes the educator's job to establish those relevant cognitive structures into which the new information can be subsumed (Ausubel, 1963). A recent article reviewing studies concerning the structure of human memory and consequent educational implications (Kumar, 1971)

generally concurs with Ausubel's notions, stating that if the speed and efficiency of processing is to be increased, then appropriate cognitive structures must be developed. "Control over meaningful learning," then, says Ausubel, "can be exercised most effectively by identifying and manipulating significant cognitive structure variables" (1963, p.8).

Thematic Effects: Nonspecific facilitated learning

The studies which have guided the way for those seeking to establish inter-passage facilitory transfer by identifying and manipulating cognitive structure variables have been those which demonstrated nonspecific facilitated learning by making reference to information known by the subject. Dooling and Lachman (1971), for example, attempting to show that knowledge of theme would facilitate passage retention, presented subjects with vague and highly metaphorical passages and either told subjects the themes of the stories or withheld them. The stories were about known events such as Christopher Columbus' discovery of America or man's first flight to the moon, so that subjects had appropriate cognitive structures into which to assimilate the information, but they could not put these structures to use unless given thematic information about the stories. Those subjects informed of the theme prior to reading the stories recalled significantly more words from them than did subjects not told the theme.

Further research by Dooling and his associates has shown that 1) knowledge of the theme must be available before, as opposed to after, reading a story and before recall (Dooling & Mullet, 1973); 2) that preexperimental knowledge of a fami-

liar topic may induce false recognitions of thematically related new sentences (Sulin & Dooling, 1974); and 3) that thematic knowledge must be available before reading in order for thematic intrusion errors to occur (Dooling & Christianson, 1974). All of these indicate that prior knowledge influences storage and facilitates retention of new incoming information.

The importance of prior knowledge has also become evident in recent studies of memory for sentential information and inferences (Johnson, Bransford & Solomon, 1973; Barclay, 1973; Bransford, Barclay & Franks, 1972). All conclude that comprehension and retention depend not only on what a subject hears or reads, but also on the implications of this information in light of relevant knowledge he already possesses. These studies specifically showed that sentential information is assimilated into existing cognitive structures so that tacit inferences are mistakenly recognized as information formerly presented.

A notable exception to the findings reported above with regard to thematic effects is an experiment similar to Dooling and Lachman (1971) conducted by Bransford and Johnson (1972). They, too, used materials for which the appropriate contexts should be part of the preexperimental knowledge of the subjects and gave some of their subjects thematic information to activate the appropriate context. Subjects with thematic information did not, however, perform differently from subjects without such information. The passage described the activities of a man as he shaved, had breakfast, and left his home in the morning, and the intended thematic cue was that the man was

unemployed. This failure to find enhanced recall and comprehension and the difference between this passage and those used by Dooling and Lachman suggested to Royer and Cable (1975) that such a facilitory effect would be present only under very specific conditions. Their hypothesis was that facilitated learning of a second passage as a function of reading an initial passage would be likely to occur only when the material presented in the second passage is difficult to comprehend without benefit of the first.

Facilitory Transfer in Prose Learning

Given the supposition that the second passage must be difficult to comprehend, Royer and Cable still had the problem of what the initial passage must contain to facilitate learning of the second. The results of a study by Pezdek and Royer (1974) suggested a possible solution. Their study was related to an experiment by Begg and Paivio (1969), which reported that subjects recognized wording changes better than meaning changes in abstract sentences while they recognized meaning changes better than wording changes in concrete sentences. Proceeding on the assumption that this result might be attributed to inadequate subject comprehension of the abstract sentences, Pezdek and Royer demonstrated that the comprehensibility of abstract sentences could be enhanced by embedding them in paragraphs with concrete referents to the material in the abstract sentences. Royer and Cable reasoned that a logical extension of this result would be to attempt to optimize the conditions under which facilitative transfer between passages would occur by constructing an initial passage containing con-

crete referents that would make the information in the second passage more comprehensible and memorable. The initial passage, in other words, should establish a knowledge "bridge" between information the subject already knows and the difficult to understand information he will be asked to learn.

Royer and Cable subsequently constructed two passages, one dealing with the flow of heat through metals (H) and the other dealing with electrical conductivity through metals (E). The format of the passages was such that an initial section described the specific phenomenon (heat flow or electrical conductivity), a middle section, similar in both passages, described the molecular structure of metals, and a final section described factors which affect electrical conductivity or heat flow. In addition, each passage was prepared in a concrete version (C), which included physical analogies for much of the information presented, and an abstract version (A), which was as devoid of concrete referents as possible. Since it was necessary to show that any facilitation that occurs is not due to specific transfer sources, Royer and Cable pretested the passages using the Cloze procedure, a completion type test prepared by deleting every nth word of a passage (Taylor, 1957; see Rankin, 1964 for review of studies on the Cloze procedure). In the pretest phase of the experiment, subjects read a complete version of either the H or E passage, followed by a mutilated version of the other passage. For the purposes of scoring and analyses, Royer and Cable subjectively parsed each passage into "idea units," and any idea units containing blanks that showed positive or negative trans-

fer from a subject having been exposed to a relevant initial passage as compared to a control subject were deleted from the subsequent analyses.

In the main phase of the experiment, subjects were exposed to either a concrete or an abstract version of one topic, followed by the concrete or abstract version of the second topic, with all pairings represented. Control groups read a control passage first, followed by either the concrete or abstract version of either topic. The results of the Royer and Cable study testing all combinations of concrete, abstract, and control passages were that subjects who had received a concrete initial passage followed by an abstract passage retained at least 40% more material from the second passage than did subjects receiving an abstract or control passage followed by an abstract passage. As predicted, groups receiving a concrete second passage (A-C, C-C, and Control-C) did not differ in recall. These results were interpreted as indicating that an initial passage can establish a relevant knowledge structure into which more difficult material can be assimilated. The fact that groups receiving a concrete second passage did not differ in recall is consonant with the assumption that the concrete passages are understandable in and of themselves, that is, easily subsumed into existing cognitive structures.

An implication of the above study is that any procedure that established that necessary "bridge" between pre-existing knowledge and to-be-acquired information should produce the facilitative effect, and Cable and Royer (in press) proceeded to test this hypothesis by supplementing the text with illus-

trations and adding verbal analogies to the abstract passages (this to show that the facilitory effect was not due to the "style" of the initial passage). Testing conditions Control-A, A-A, C-A, A with analogies-A (Aa-A), and A with illustrations-A (Ai-A), Cable and Royer supported their predictions in that subjects in the C-A, Aa-A, and Ai-A conditions performed significantly better than those in the non-facilitory conditions, A-A and Control-A.

Finally, if the concept of a knowledge "bridge," as demonstrated in the above two studies, is to be of any significance in education, then the established structures must be relatively permanent, i.e., that the facilitory effects of the initial passage persist over a period of time. Perkins and Royer (1975) tested this hypothesis by exposing subjects to a concrete or control initial passage and then having them read and recall an abstract passage either immediately, two days later, or a week later. Results showed that the only reliable effect was the treatment effect with C-A subjects performing better than Control-A subjects. The period of delay had no effect, nor did the treatment and interval variables interact.

Summary and Implications

The importance of the Royer and Cable, Cable and Royer, and Perkins and Royer studies is that they have demonstrated that reliable and sizeable facilitory learning effects can occur when subjects are cognitively prepared to learn new, difficult to understand materials, and that established appropriate cognitive structures will persist over time. The impli-

cations for education are clear; guidelines could be provided for the development of curriculum materials such that a student would rarely encounter information that he was unprepared to learn. But before these studies can be of educational usefulness, several questions remain to be answered.

First of all, will the facilitory effects noted in these studies hold with genuine instructional materials which students have demonstrable difficulty in learning? The three reported studies showing facilitory transfer have been conducted in the laboratory with carefully constructed laboratory materials, which makes their generalizability to natural settings an open question. The prospect of producing the effect in the classroom is not at all frightening to Ausubel who contends that the most typical practice in texts is to segregate topically homogeneous material into separate chapters and present them at a uniform level of conceptualization. The result of this type of inefficient organization is that "vague, diffuse, ambiguous, or erroneous meanings may emerge from the very beginning of the learning process because of the unavailability of relevant, inclusive, subsumers in cognitive structures" (Ausubel, 1963, p.50); students would therefore be forced to rote learn or attempt to use some tangentially related subsumers. Any technique, then, that establishes the type of cognitive structure that would facilitate later assimilation of more advanced material should be of enormous benefit to all students.

An unexpected finding of Guthrie (1972), who was investigating the relationship between learnability of prose pas-

sages and their readability as predicted by readability formulae, also supports the supposition that instructional materials can be benefitted by organizational strategies such as those suggested by Ausubel. Guthrie used reading materials taken from textbooks commonly used in elementary and high schools which varied in difficulty from second to twelfth grade, and discovered that students had less prior knowledge of passages which contained highly complex linguistic structures and further that less learning is likely to occur with linguistically difficult materials. "The resulting paradox is that unfamiliar reading material, for which a considerable amount of learning must occur, is written in a complex form which minimizes the likelihood that new learning will occur. . . . It would be useful to attempt to construct reading materials which communicate unfamiliar topics with simple grammatical structure. In this manner the acquisition of unfamiliar bodies of knowledge might be facilitated" (Guthrie, 1972, p.279). Acquisition of such unfamiliar bodies of knowledge might also be facilitated by initially exposing students to material that would establish the appropriate cognitive structures for comprehending that information.

Another major question raised by facilitative transfer research is whether or not younger subject populations would also exhibit facilitated learning as a result of the establishment of appropriate cognitive structures. Studies up to now have been conducted exclusively with adults--college students--and yet their implications could affect those students as young as beginning readers. According to Ausubel (1963), children's

cognitive organization differs from that of adults in containing fewer abstract concepts, fewer higher order abstractions, and more intuitive-nonverbal understandings. He suggests that children's learning can, however, proceed similarly to that of adults as long as abstract concepts and definitions are systematically related to concrete-empirical experience.

Research of this sort with children is virtually nonexistent. Inhelder (1969) has conducted studies of children's memory for perceptual events within the framework of Piaget's theory of cognitive development and has shown a structuring and restructuring of a mnemonic memory code in accordance with development. Extensive research in children's paired-associate learning has demonstrated differential use of verbal mediators (see Flavell, 1970, for review) and imagery strategies (e.g., Lynch and Rohwer, 1972; Horvitz and Levin, 1972; see Rohwer, 1973, and Lesgold et al, 1974, for excellent reviews of this literature) which are related to developmental factors and to facilitated PA learning. Very young children (less than 6 or 7 years old) cannot make use of an imagery strategy to facilitate learning; children around the ages of 9 will use and benefit from an imagery strategy after a training period in the specific learned skills related to the strategy and instructions to use; and older children and adults spontaneously make use of imagery strategies, with increased levels of performance in imagery/illustration tasks after specific instructions to use the strategies.

Only one study reported in Rohwer (1973) conducted by Rohwer and Matz used textual materials with grade school chil-

dren. Fourth grade subjects were read prose passages and then asked to indicate whether each sentence was consistent with the information contained in the passage. Again, though, Kohler and Matz were interested in the effect of pictorial prompts so that half the subjects saw the printed text (verbal condition) and half saw drawings of the information presented (pictorial condition). Results showed that the prompt effect was significant, with low SES students benefitting to a greater degree from the pictorial prompt than high SES students.

Problem

One purpose of this study is to investigate the possibility of establishing a knowledge "bridge" between prior knowledge and to-be-acquired information in grade school children in order to facilitate learning of difficult to comprehend instructional materials. A second objective is to extend the results of the previous studies, which used laboratory materials, to genuine instructional materials. The instructional passages to be used in this study, in other words, will be drawn from topic areas in science that, according to their grade school teachers, the students generally have difficulty learning.

The study consists of 12 groups, presented in Table 1, which constitute four 1-factor designs. Each separate design includes only those groups of subjects receiving the same second passage, and the treatment in all designs is the type of first passage received. Therefore, groups 1, 5, and 9 will form the basis of one analysis, groups 2, 6, and 10 form the basis of another, and so forth.

Table 1: Design

<u>Group</u>	<u>First Passage</u>		<u>Second Passage</u>	
	<u>type</u>	<u>topic</u>	<u>type</u>	<u>topic</u>
1	A	Heat Flow	C	Electricity
2	A	Electricity	C	Heat Flow
3	A	Heat Flow	A	Electricity
4	A	Electricity	A	Heat Flow
5	C	Heat Flow	C	Electricity
6	C	Electricity	C	Heat Flow
7	C	Heat Flow	A	Electricity
8	C	Electricity	A	Heat Flow
9	Control		C	Electricity
10	Control		C	Heat Flow
11	Control		A	Electricity
12	Control		A	Heat Flow

The predictions for the study are:

- a) There will be no differences among groups when the second passage received is concrete. Specifically, recall of subjects in the Control-EC, HA-EC, and HC-EC conditions (groups 1, 5, and 9) should be comparable and performance of subjects in the Control-HC, EA-HC, and EC-HC conditions (groups 2, 6, and 10) should be equivalent.
- b) The effect of interest is that expected when the second passage received by subjects is abstract. Here, groups reading a concrete passage first, followed by the abstract passage, should perform significantly better than groups receiving a control or another abstract passage first; the Control-A and A-A groups are not expected to differ from one another. Subjects in the HC-EA condition (group 7), therefore, are expected to outperform those in the HA-EA and Control-EA conditions (groups 3 and 11); likewise, subjects in the EC-HA condition (group 8) are expected to perform better

than those in the EA-HA and Control-HA conditions (groups 4 and 12).

In order to reduce overall variability, reading level of the children will be used as a covariate in the experiment.

METHOD

Subjects: One hundred and twenty-seven fifth grade children from four classes in the Greenfield, Massachusetts, elementary school system participated in the study. The final distribution of subjects in experimental groups is presented in Table 2. Stanford Achievement Reading Comprehension Test Scores were collected for all subjects in order to account for variability in the data due to disparate reading levels of subjects. The means of these scores for each group are also presented in Table 2.

Table 2

Distribution of subjects in experimental groups
and mean reading comprehension scores
reported in grade equivalencies

Topic of 2nd passage	Treatment	# of <u>Ss</u>	Mean S.A.T.
Heat Flow	C*-C	10	4.9
	A**-C	10	5.7
	Control-C	10	5.1
	A-A	11	5.2
	C-A	12	5.4
	Control-A	10	4.7
Electrical Conductivity	C-C	11	5.2
	A-C	11	5.3
	Control-C	10	6.0
	A-A	10	5.4
	C-A	12	5.0
	Control-A	10	5.3

*Concrete

**Abstract

@Grade equivalency scores from test administered in Nov, 1978

Materials: Given the specifications formulated by Royer and

Cable (1975) and the judgment of the teachers that their students generally experience difficulty understanding electricity and related topics, experimental materials were prepared from existing fifth and sixth grade science instruction that directly paralleled the heat flow and electrical conductivity passages used by Royer and Cable. The H and E passages, therefore, were written in two separate versions; one version was constructed to provide concrete referents (C) for much of the information presented so that it would be easy to comprehend in and of itself, and the other version was written so that it would be abstract (A) in nature, or lacking in concrete referents, and would be more difficult to understand without benefit of a prior knowledge structure by which to organize the incoming information. The actual composition of each passage was similar; all began with an initial segment describing the specific phenomenon (H or E), followed by a section describing the structure of metals, with a final section discussing factors which affect electrical conductivity or heat flow. A control passage describing various types of plants and how they are germinated was also constructed. The word lengths for the respective passages were: HC-394 words, HA-356 words, EC-336 words, EA-300 words, and Control-300 words.

Criterion tests for both versions of the H and E passages were constructed to serve as a retention measure, since it was suspected that instructions to fifth grade children to free recall would be difficult for them either to understand or to follow. The tests each consisted of 15 items in a multiple choice format. For samples of all materials, see Appendix A.

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Pretesting the materials: Ten fifth and sixth grade children from the Marks Meadow Elementary School participated in a preliminary testing of the materials to determine two things: whether the materials were, indeed, at an appropriate reading level for the subjects, and whether subjects would respond to instructions to free recall. Subjects were given one of the five passages and asked to read it slowly and carefully twice. When all had finished reading, half were asked to complete the appropriate criterion quiz on their passage and the remaining half were given blank sheets of paper and instructed to write down everything they could remember from the passage they had just read. These latter subjects were encouraged to write down what they remembered in any form they could--pictures, incomplete sentences, etc.--and told that spelling was not important. All subjects had as much time as they needed to complete the task. When everyone had finished, the experimenter asked questions about the passages to get informal reactions to such factors as the vocabulary level, difficulty of style, etc. All subjects felt that the passages were within their reading capabilities, but, as expected, the abstract passages were thought to be much more difficult to understand. Results of the criterion quizzes showed the level of recall to be high (means were 90% correct for the concrete passages and 57% correct for the abstract passages), whereas free recall protocols were, on the average, not more than one or two sentences long. Subjects in the free recall condition voiced the desire to take the quiz since they felt they remembered more and just did not know how to write it all down.

Procedure: In the main phase of the experiment, the subjects were run in their regular classrooms during either their science or reading periods. The groups ranged in size from 25 to 35 children. Individual envelopes containing all the experimental materials (1st passage, 2nd passage, criterion quiz) were distributed randomly to subjects with the initial instruction that they were not to look inside until told to do so. The envelopes had been prearranged in sequence so that all experimental groups would be equally represented in each classroom. When all children had received an envelope, the format of the experiment was explained and general instructions were reviewed. The children were told that the experiment involved reading two stories and then completing a short quiz composed of questions about one of the stories. They were also told that the stories they each were reading would be different from those being read by their neighbors so that it was important they pay attention to their own materials and do the best they could. It was further explained that they would be timed on their reading of the second passage but that they would have as much time as they needed to read the first passage and to complete the criterion quiz. Subjects were then instructed to remove the first passage (appropriately marked) from their envelope and to read the passage slowly and carefully twice. When they finished they were to sit quietly and wait for the rest of the class to finish. When all subjects had finished reading, they were asked to replace the first passage and remove the second passage. Reading of this passage was timed by the experimenter so that subjects had 2 minutes to read each page (there were

3 pages), with the stipulation that they could not refer back to a previous page or look ahead to a future page. When this was completed, subjects were told to replace the passage and begin on the criterion quiz. They were given unlimited time to answer the questions on the quiz, following which envelopes were collected and the purpose of the experiment was explained. Any questions about what the results would demonstrate were answered at this time.

Scoring and Analysis: The criterion quizzes for each group were scored twice, once for the number of correctly answered questions and the second time for the proportion of correctly recalled idea units, as defined by Royer and Cable's (1975) criteria. The reason for the second scoring of the data was that quiz questions were found to require the subjects to recall different amounts of information, so that a score based just on the number of correctly answered questions might not accurately reflect how much a subject recalled. It would be conceivable, for example, for two subjects with the same number correct to actually be recalling different amounts of information. The number of idea units for each passage was HC-57, HA-52, EC-47, and EA-43, and the number of idea units required for completing each quiz was HC-30, HA-35, EA-30, and EC-26. Although all the data was scored by the experimenter, inter-scorer reliability using Royer and Cable's procedure has been demonstrably high, greater than 96%. Analyses were then performed on both the criterion test scores and the proportion of correctly recalled idea units from the tests.

The distribution of errors and correct responses for all

question on each criterion quiz was also recorded, followed by a categorization of the questions into the following groups: general, interfering, and facilitating. Although the passages were constructed in such a way as to minimize specific transfer, it was noted that some of the questions were of a form that would be sensitive to specific facilitative and interference effects of one passage on the other. The proportions of correct responses on each type of question in the treatment groups were subsequently compared to those in the control groups.

RESULTS

Overall Criterion Test

The number of correctly recalled criterion test questions, the proportion of correctly recalled idea units, and the reading comprehension scores for each subject can be found in Appendix B. Mean criterion test scores and mean proportion recalled idea units as a function of treatment are summarized in Tables 3 and 4, respectively.

Table 3

Mean criterion test scores as a function of treatment

Topic of 2nd Passage	Treatment	Mean	Std. Deviation
Heat Flow	C-C	6.91*	2.91
	A-C	7.82	3.25
	Control-C	7.09	2.17
	A-A	6.80	1.93
	C-A	7.40	2.63
	Control-A	6.60	2.95
Electrical Conductivity	C-C	6.50	2.64
	A-C	5.90	2.57
	Control-C	8.50	4.77
	A-A	6.50	3.17
	C-A	6.70	2.45
	Control-A	7.60	4.33

*The means for the groups receiving HC as a second passage are based on 11 subjects/group. All other means are based on 10 subjects/group.

Table 4

Mean percent idea units recalled as a function of treatment

Topic of 2nd Passage	Treatment	Mean	Stnd. Deviation
Heat Flow	C-C	41.66	19.65
	A-C	53.00	26.12
	Control-C	50.33	18.27
	A-A	49.42	17.57
	C-A	48.86	15.32
	Control-A	47.98	20.64
Electrical	C-C	40.76	16.25
	A-C	36.53	19.46
	Control-C	55.76	31.79
	A-A	42.99	24.20
	C-A	39.66	18.16
	Control-A	50.33	30.78

Because the four passages differed in length and content, it did not seem logically appropriate to combine them in a single analysis; as a result, separate analyses of variance were performed on the passages such that each analysis included only those scores of subjects tested on the same second passage--EC, EC, HA or EA. The treatment variable in each analysis, then, was the type of first passage read by the subject, whether concrete, abstract or control. In order to obtain equal n in all groups to facilitate data analysis, random scores were deleted from groups containing more than 10 subjects. The analyses of variance performed on criterion test scores are presented in Table 5, along with the results of an analysis collapsing over topic of second passage. In all but one analysis, F-ratios were less than 1, the exception being the EC-second passage analysis in which $F_{2,27} = 1.54$. All F's were non-significant.

Table 5

Analysis of Variance comparison of type of 1st passage
on 2nd passage criterion tests

Topic of 2nd passage		df	MS	F	p
Heat-Concrete	A	2	2.55	<1	ns
	S/A	27	7.97		
Elec.-Concrete	A	2	18.54	1.54	ns
	S/A	27	12.07		
Heat-Abstract	A	2	1.74	<1	ns
	S/A	27	6.46		
Elec.-Abstract	A	2	3.44	<1	ns
	S/A	27	11.59		
Concrete	A	2	6.54	<1	ns
	S/A	57	9.90		
Abstract	A	2	1.22	<1	ns
	S/A	57	8.69		

The analyses of variance of the proportion of correctly recalled idea units are presented in Table 6, with the results being very similar to those of the criterion test scores analyses. Again, in all but the EC analysis, F-ratios were less than one and therefore non-significant. In the EC analysis, $F_{2,27}$ equalled 1.85, also non-significant. Collapsing over topic of second passage produced a slight change in results from those presented in Table 5, in that the effect of the type of first passage (treatment variable) in the concrete second passage group approached significance ($F_{2,27} = 3.09$, $p < .10$). The treatment effect in the abstract passage group, however, remained non-

significant.

Table 6

Analysis of Variance comparison of type of 1st passage read on percent correct idea units recalled from 2nd passage

Topic of 2nd Passage		df	MS	F	p
Heat-Concrete	A	2	351.49	< 1	ns
	S/A	27	467.49		
Elec.-Concrete	A	2	1021.15	1.85	ns
	S/A	27	551.22		
Heat-Abstract	A	2	112.58	< 1	ns
	S/A	27	323.11		
Elec.-Abstract	A	2	298.03	< 1	ns
	S/A	27	620.89		
Concrete	A	2	1491.44	3.09	< .10
	S/A	57	482.55		
Abstract	A	2	512.91	1.15	ns
	S/A	57	447.16		

The fact that the results presented above were non-significant is not undeniable evidence that a treatment effect is lacking in the data. The experimental task was primarily a reading task and fifth graders can be expected to differ widely with respect to their reading achievement levels. It is quite conceivable, then, that despite random assignment of subjects to groups, within groups variability due to differing reading levels may have obscured between groups variability due to treatment. Consequently, an analysis of covariance with reading comprehension scores as the covariate was judged to be applicable. For com-

putational ease, only criterion test scores were used as the dependent measure, justification for this being the lack of difference between this measure and the proportion of correctly recalled idea units. Since the extent to which an analysis of the adjusted variances will result in a significance level different from that based on an analysis of the unadjusted variances depends not only on the size of the differences between groups on the dependent measure and the covariate but also on the degree of the correlation between the two variables (McNemar, 1969), Pearson product-moment correlations between the criterion test scores and reading comprehension scores (Nunnally, 1967) were calculated for each group and overall. As shown in Table 7, the correlations range from $-.004$ to $+.900$, with the overall correlation being $.395$. Although the variability in the values of the correlations across groups is high, this can probably be attributed to the small n in each group, so that the overall correlation is likely to be a more accurate estimate of the true correlation, and this was judged to be high enough to warrant an analysis of covariance.

Table 7

Pearson PM correlations between criterion test scores and reading comprehension scores for each group

<u>2nd Passage</u>		<u>1st Passage</u>		
topic	type	Control	Concrete	Abstract
Heat	C	.232	-.004	.193
	A	.527	.553	.269
Elec.	C	.659	.061	.553
	A	.900	.571	.150

Analyses of covariances were then performed on groups receiving the same second passage, and these results are summarized in Table 8. In all cases, the test for homogeneity of regression coefficients was non-significant, indicating that that assumption had been met, and in all cases, results were non-significant ($F < 1$).

Table 8

Analysis of Covariance comparisons of type of 1st passage read on 2nd passage criterion tests, with reading comprehension scores as the covariate

Topic of 2nd Passage		df	MS	F	p
Heat-Concrete	A _{adj.}	2	1.085	< 1	ns
	S/A _{adj.}	23	7.457		
Elec.-Concrete	A _{adj.}	2	5.369	< 1	ns
	S/A _{adj.}	17	11.142		
Heat-Abstract	A _{adj.}	2	.39	< 1	ns
	S/A _{adj.}	20	6.925		
Elec.-Abstract	A _{adj.}	2	1.876	< 1	ns
	S/A _{adj.}	23	9.26		

Analysis by Type of Question

The distribution of errors and correct responses on all four criterion tests as a function of treatment group can be found in Appendix C. The proportions of correct responses for each type of question--general, interference, and facilitation--in each treatment group are presented in Table 9. Standard Z-tests for differences between two proportions (Walker & Lev, 1953) yielded only three significant comparisons at the .05 level.

Subjects in the Control-EC group performed significantly better than subjects in the HA-EC group on interference questions (.633 to .394, $Z \sim 2.69$, one-tailed¹); subjects in the EA-HC group performed better than those in the Control-HC group on facilitation questions (.80 to .60, $Z \sim 1.70$, one-tailed); and subjects in the Control-EC group outperformed those in the HC-EC group on general questions (.55 to .33, $Z \sim 2.17$, two-tailed). The trend apparent in the comparison of the EC-HA condition to the Control-HA condition is consistent with the hypothesis being tested in the experiment, in that performance is improved from control to treatment on general and facilitation questions, with interference questions showing decreased performance. Compromising this finding, however, is the fact that only the performance on general questions remains improved when the EC-HA condition is compared to the corresponding EA-HA condition. The analogous comparisons, considering the groups receiving the E passage second, show a decrease in performance from the Control-EA condition to the HC-EA and HA-EA conditions, with performance for the HC-EA group being lower than for the HA-EA group.

Collapsing over type of passage and considering only experimental versus control first passages as the relevant variable, we find that certain trends in the mean proportion of correct responses across groups in each type of question become apparent (see Table 10). In the Control-E and Control-H groups, no differences in proportion would be expected across type of question

¹Comparisons involving performance on facilitation or interference questions were one-tailed, because deviation was predicted in only one direction. In comparisons involving performance on general questions, however, deviation in either direction was of interest; hence, these comparisons were two-tailed.

since all questions could be categorized as general for those groups; and, indeed, this appears to hold, at least for the Control-H group. Comparing control to treatment groups, the trend for groups receiving E as the second passage is for treatment groups (receiving an initial H passage) to perform worse than the control groups on all types of questions. For groups receiving H as the second passage, the trend reveals treatment groups performing about the same as the controls on general questions, worse on interference questions, and better on facilitation questions.

Table 9

Mean percent correct responses on general, interference and facilitation questions of the criterion tests
as a function of treatment

<u>2nd Passage</u>		Type of Question	<u>1st Passage</u>		
topic	type		Control	Concrete	Abstract
Heat	C	Gen'l	.500	.443	.500
		Int.	.400	.409	.400
		Fac.	.600	.576	.300
	A	Gen'l	.450	.562	.489
		Int.	.450	.292	.386
		Fac.	.400	.472	.515
Elec.	C	Gen'l	.550	.330	.409
		Int.	.633	.515	.394
		Fac.	.400	.455	.364
	A	Gen'l	.500	.448	.426
		Int.	.514	.407	.492
		Fac.	.500	.308	.389

Table 10

Mean percent correct responses in each type
of test question, collapsing over type of passage

<u>2nd Passage</u>	Type of Question	<u>1st Passage</u>	
		Control	Experimental
Heat	Gen'l	.48	.50
	Int.	.43	.37
	Fac.	.50	.59
Electrical	Gen'l	.53	.41
	Int.	.57	.45
	Fac.	.45	.38

DISCUSSION

"Prose materials are most readily learned when they make contact with and can be assimilated into existing knowledge structure" (Royer & Cable, 1975, p.121); and the first major purpose of this study was to attempt to facilitate children's learning of difficult to comprehend prose materials by exposing the children to initial passages that would make contact with existing knowledge structure. By relating concepts with which the child was already very familiar to prerequisite knowledge of the difficult information that was to be learned, these initial passages would serve as a sort of knowledge "bridge" between the child's prior knowledge and the critical information that was later tested. Royer and his associates have repeatedly demonstrated facilitory learning effects with adults, and this study attempted to generalize their findings to include children's learning.

The second objective of the study was to extend the research beyond the laboratory, to investigate whether, in fact, such a facilitory learning effect as described above would hold up with instructional materials directly relevant to the classroom. In order for the effect to have any significant educational implications, it must be the case that it will hold up in a classroom setting.

Unfortunately, the results of the experiment did not support the specific prediction that children receiving a concrete written passage prior to learning a more difficult, abstract

passage would perform better on the criterion test than those children receiving either a control or another abstract passage first. The hypothesis was that a concrete passage, one that contained many analogies and concrete referents to facts already known by the children, would set up relevant knowledge structure for learning the abstract passage. This structure would be absent from the knowledge bases of those children reading unrelated first passages or other abstract first passages. Yet the evidence seems overwhelmingly to indicate no difference between groups. None of the analyses of variance were significant at the .05 level, and none of the analyses of covariance, which adjusted for the variability due to reading level, were significant. A couple of straws to grasp at, perhaps, are the trend in the criterion test means of the groups receiving HA as the second passage, which is in the right direction (C-A > A-A or Control-A), and the standard deviations of the C-A groups, which are smaller than most of those of the other groups. That the equivalent means of the groups receiving EA as the second passage do not follow the same trend as the HA groups is a fact which may be attributable to other problems with the E passages, to be discussed later.

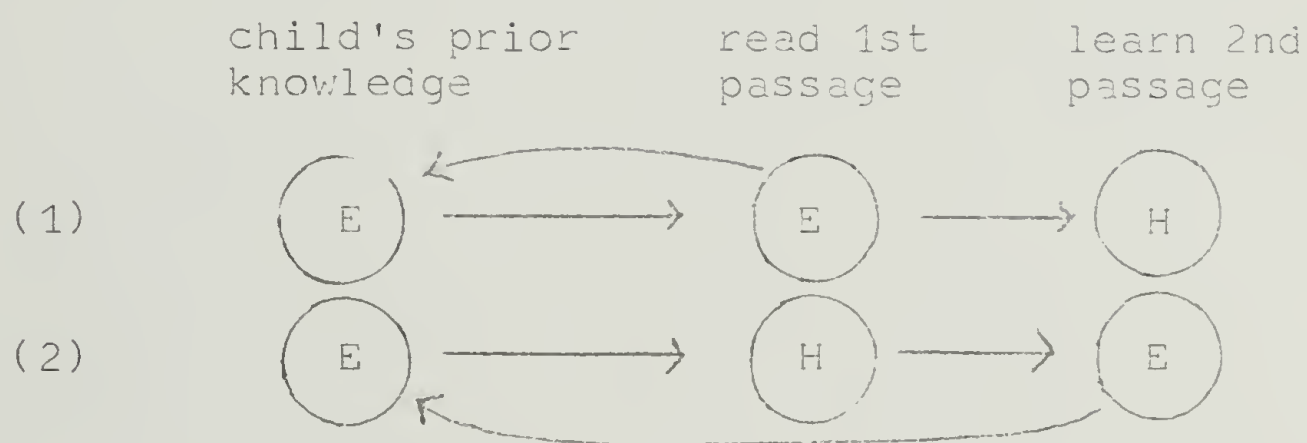
Before automatically rejecting the original hypothesis, then, or reaching the conclusion that the facilitory learning effect does not extend beyond a laboratory setting, it would be wise to first consider all of the other possible factors which could account for, or at least contribute to, the findings, or lack thereof, in this study. These factors fall into a number of distinct categories which will each be examined in turn.

The first possible explanation of the lack of a facilitory learning effect is that the concrete and abstract passages might have been indiscriminable in difficulty. They might both have been easy to comprehend so that whatever additional information or knowledge structure to be garnered from the concrete passage was simply unnecessary for the process of learning the information in the abstract passage. Or, both passages might have been equally difficult such that neither made contact with existing knowledge structure in the child's memory; in this case, the analogies and concrete referents included in the concrete passages would have to have been outside the realm of the child's concrete-empirical experience and, consequently, of no use as explanatory concepts. These first two possibilities are indistinguishable in the results they would predict for this study, which are that performance in the abstract and concrete passages of the same topic should be comparable, regardless of what was read as an initial passage; their only difference would be in predicted absolute level of recall--easy passages should produce higher recall than difficult ones--and this difference could not have been demonstrated by the present experiment. A third possibility is that the relation between the two types of passages--concrete and abstract--was somehow obscure, so that the concrete passages might have made contact with the child's knowledge base but still failed in setting up the relevant subsuming structure for learning the abstract passage. This would predict that concrete passages would be recalled better than abstract passages of the same topic, without regard to initial passages. While the above explanation of the lack of treatment

effect cannot be completely discounted (since the adult experimenter cannot judge the difficulty of the passages exactly as a child would), it can be deemphasized, based on the data and the informal reactions of the children who participated in the pretesting of the materials. The data do not clearly support either of the predictions resulting from the three stated possibilities. There were no statistical differences among groups receiving the same second passage, but comparing recall for concrete versus abstract within a topic shows a difference for H passages and no difference for E passages, though this was not statistically tested. As far as the pretest data are concerned, all of these subjects thought (and this was verified by their criterion pretest scores) that the concrete passages were much easier to understand and remember than the abstract passages.

An alternative way of accounting for the study's findings is related to the question of the generalizability of the learning effect to the classroom environment. The claim can be made, not that the effect will not generalize to any classroom, but that the particular setting chosen for the experiment involved mitigating circumstances. To begin with, the four classes involved in the study came from four different elementary schools within the one school system, and although subjects were randomly assigned to groups so that all four schools were approximately equally represented in each group, unknown factors accounting for differences among schools may have interacted with the treatment variable. A more likely occurrence, however, is that the particular learning histories of these children interacted with

the materials used in the experiment. For example, the results presented in Tables 9 and 10 suggest that reading an H passage interfered with the learning of an E passage since in nearly all instances, the proportion of correct answers in the control groups exceeded that in the experimental groups. The reverse, however, does not appear to be true, i.e., that reading an E passage interfered with the learning of an H passage. That the problem is not simply with the E passages alone is evident from the proportion correct of those subjects in the Control-EC and Control-EA conditions, which are two of the highest in the experiment. The science curriculum used in the schools approaches scientific phenomena in a very concrete, empirical fashion and provides the children with a more complete exposure to the concept of electrical conductivity as it is discussed in the passages than to the concept of heat flow. The following diagram, then, characterizes what might have occurred in the experiment:



Having some prior knowledge structure about electricity, a child reading the E passage first, as in row (1), could have subsumed the material being presented about electricity and subsequently built the appropriate knowledge structure for learning the information in the H passage which followed. A child reading the H passage first (row 2), on the other hand, would have had no relevant subsumers for that information so that whatever was retained

from that passage might then have interfered with the process of relating the following E passage back to the knowledge base. The obvious implication of this is that there is need for more careful analysis of exactly what the child knows in order for materials to be constructed that will make contact with this knowledge base.

Related to the notion of analyzing the child's knowledge base is the hypothesis that children's cognitive organization might differ from that of adults more radically than was originally expected and this might account for the results of the study. Ausubel (1963) had suggested that children's cognitive organization only contained fewer abstract concepts and more intuitive-nonverbal understandings than adults but that their learning should proceed similarly to that of adults when these factors were taken into consideration. Recent evidence (Paris, 1975) suggests that there are developmental changes in constructive memory, including those processes which "determine how one acts upon new information, what significance it achieves and how it is incorporated within one's extant schemata" (p.24); older children, in other words, are more able to construct full, integrated, and meaningful memory representations of what they experience. This evidence, however, along with the support for semantic integration in children's recall of prose presented by Barclay and Reid (1974), also shows these abilities to have developed by the fifth grade. The hypothesis of this study, then, should have been supported. Flavell (1975) suggests a reason for why it was not.

As mentioned earlier in this paper, research on children's

use of mediational strategies has shown a developmental trend in the spontaneous use of strategies, i.e., in a certain age range, children may know how to make use of a particular strategy but they do not use it unless given specific instructions to do so. And Flavell (1975) lists a number of reasons for the occurrence of this production deficiency, including the hypotheses that the child is insufficiently "planful" or "goal-oriented" in the memory-task situation and that other, less efficient strategies, which have been in the child's repertoire longer, may be called forth. In the present study, it may be the case that the children could relate the concrete initial passage to their knowledge base and later relate the abstract passage to the activated relevant structure, but that they did not, for whatever reason. The intuitions of the participating teachers were that the children needed more specific instructions to think about the relations between the initial passages and what they already knew and between the passages themselves, and that the children needed to be reminded about the importance of learning and remembering the information contained in the second passage. Perhaps, with these more specific instructions, the facilitatory learning effect would become evident. A further suggestion of the teachers was to lengthen the experiment to more than one session. It was their feeling that since the children were unaccustomed to the experimental task, increased practice with the same types of materials might result in increasing treatment effects.

One final factor which almost certainly affected the findings of this study is related to the actual design of the exper-

iment. Hindsight on the part of the experimenter suggests that the dependent measure used in the study was simply not sensitive to the hypothesized facilitory learning effect. Although written free recall was tested and judged to be inadequate for the purposes of the study, oral free recall was never considered. Throughout the experiment, children expressed difficulties with the criterion tests, although they felt it was easier to take than writing down what they remembered. A more sensitive procedure, however, would have been testing each child individually and recording all of his/her responses.

SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

Since there is always some probability of accepting a false null hypothesis, failing to reject the null hypothesis in favor of a desirable alternative does not automatically mean throwing out the desirable alternative. Often it indicates to the researcher the necessity of altering experimental conditions to further reduce sample variability, and thereby increase the power of the test of the hypothesis, or of altering the questions the researcher is asking. Such is the state of affairs in this study. The experiment did not produce a facilitory learning effect with children and it did not generalize previous findings to genuine instructional materials with this particular set of classrooms, but it does suggest a number of possible ways of proceeding from here, with the original questions in mind.

An obvious first step is to carefully analyze the passages used in the study and the prior knowledge the children have about the specific topics. Teachers should be more heavily relied upon to provide information about topics or subtopics the children have acquired some knowledge about, and the form of this knowledge, as well as those topics with which the children experience difficulty, and exactly how this difficulty is manifested. Some sort of pretest might also be administered to obtain information about the knowledge bases of the children with regard to the passage topics. Analyses of the passages could take the form of applying difficulty indices or completing linguistic analyses, but these should be followed up, in the

context of the experiment, with a testing of the initially read passages to determine exactly what the children had learned from them before they read the second passage.

This last suggestion is also important from the standpoint of testing the production deficiency hypothesis. If it could be determined that the children in the study were constructing the connections between their knowledge bases and the concrete passages but not between the concrete and subsequent abstract passages, as had been predicted, then instructions would become a relevant variable. At that point, a study should be run to determine whether, in fact, children will construct that second set of connections when given more explicit instructions to think about the relations between the two passages. If they will, the production deficiency hypothesis would become a likely explanation of the results of this study.

One of the intuitions of the teachers was that the children needed more practice on these types of materials, being unaccustomed as they were to the experimental task, to accrue any learning benefit in the C-A conditions. This leads to some interesting speculation on the possibility of structuring an entire semester or year's curriculum on the basis of the original hypothesis being tested, but it also points out the necessity of looking at other techniques for children to establish the important knowledge "bridges." Any technique which builds the relevant connections should improve recall, and it may be the case that children would respond better to other modes. Also, given the nature of the science curriculum in the schools which participated in the study, written verbal materials might

just have been inappropriate to the way in which these particular children learn but might be appropriate for other grade school populations with a heavier emphasis on verbal skills. This possibility, then, should be tested by running the study again on such a population.

In conclusion, although this study asks more questions than it answers regarding children's interaction with educational materials, it does at least offer some possible routes to follow and some pitfalls to avoid. These routes may, in turn, lead us to a better understanding of how children learn and what educational experiences will make the process of learning most efficient.

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APPENDIX A: Materials

Most materials allow some amount of electrical current to flow through themselves. When the current flows easily, the material is said to be a good conductor of electricity. This electric current is really a flow of electrons, because electrons can be pushed from one atom to another.

The best conductors of electricity are substances which are metallic. Metals are efficient conductors because they have many unbonded electrons. These unbonded electrons are free from any atoms or molecules. The molecules in any metal are arranged in a regular, rowlike fashion. There are large, open spaces between the molecules. The unbonded electrons move randomly through the spaces.

A battery is a source of unbonded electrons. When two ends of a metal wire are attached to a battery, electrons from the battery will flow into the metal. When too many electrons are at one end of the wire, some will begin to move to less crowded areas. They will flow through the wire to the other side of the battery, which has few electrons. In this way, we can get a moving current of electrons, an electric current. You can see that substances will conduct electricity best when their molecules are arranged in order. Then it is easier for the electrons to move through the wire between the molecules.

Two other things influence how well a metal will conduct electricity. These are the heat of the metal and the presence of a magnet nearby.

If a metal is hot, then its molecules will vibrate at a high speed. The vibration makes it more likely for the electrons of the current to crash into the molecules. And this increase in collision rate results in restricted current flow.

A magnet can also decrease current flow, because magnets can push electrons off the paths they were following. A magnet near a wire carrying electricity will push the electrons to the opposite side of the wire. The crowding of the current electrons into a small space will cause these electrons to move more slowly. As a result, the amount of current will be reduced.

Each question has only one correct answer. Circle the letter of the choice that best answers the question.

1. Electrical current flows easily through Substance X. Substance X is
 - a. not a conductor of electricity
 - b. a good conductor of electricity
 - c. a bad conductor of electricity
 - d. a good conductor of heat
 - e. a bad conductor of heat
2. Electrons
 - a. can be pushed from one atom to another
 - b. are always connected to atoms
 - c. are always inside molecules
 - d. cannot move from their positions
3. Electric current is
 - a. a stationary force
 - b. a transfer of motion
 - c. a flow of electrons
 - d. a flow of molecules
4. Metallic substances are
 - a. the best conductors of electricity
 - b. good, but not the best, conductors of electricity
 - c. bad conductors of electricity
 - d. not conductors of electricity at all
5. Good conductors of electricity have
 - a. many molecules
 - b. few molecules
 - c. many unbonded electrons
 - d. few unbonded electrons
6. Particles that can move anywhere in the structure of metals are called
 - a. unbonded molecules
 - b. unbonded electrons
 - c. unbonded atoms
 - d. none of the above
7. Unbonded electrons can come from
 - a. a battery
 - b. metal molecules
 - c. atoms
 - d. other electrons

8. What happens when you connect a metal wire to a battery?
- molecules flow from the battery into the metal.
 - molecules flow from the metal into the battery.
 - electrons flow from the battery into the metal.
 - the metal gets hot.
9. An electric current flows when
- the wire is in a certain position.
 - electrons and molecules vibrate.
 - electrons crash into molecules.
 - electrons move from crowded areas to less crowded areas.
10. When does an electric current flow best?
- when the molecules vibrate
 - when the electrons are arranged in order
 - when the molecules are arranged in order
 - when the electrons stand still
11. How many things affect the flow of electricity?
- one
 - two
 - three
 - none
12. Which of these will decrease current flow?
- the heat of the metal and a magnet nearby
 - pressure on the metal and the heat of the metal
 - the kind of metal and impurities in the metal
 - only impurities in the metal
 - only the heat of the metal
13. If the metal molecules vibrate, then electric current will be
- increased
 - reduced
 - unchanged
 - first increased, then reduced
 - first reduced, then increased
14. If a metal is hot,
- electrons will move more easily
 - electrons will crash into molecules more often
 - electrons will move more slowly
 - none of the above
15. If electrons are forced to slow down and move only on one side of the wire, then
- there is a magnet nearby
 - the metal is hot
 - pressure is being applied
 - impurities are present

A certain amount of electricity can flow through any kind of substance. When it is easy for the current to flow, we call the substance a good conductor of electricity. This electric current is really a flow of electrons, because electrons can be made to move from one atom to the next to the next.

The best conductors of electricity are metals. Metals are good conductors because they have a lot of free electrons. These free electrons are not connected to any atoms or molecules. They can move anywhere through the spaces between the metal molecules. Metal molecules are in straight rows. Think of a parking lot full of cars parked in neat rows. They would be like the metal molecules. Now pretend you and some of your friends are riding your bikes around the cars. You would be like the free electrons.

A battery can produce free electrons. Suppose you connect two ends of a metal wire to a battery. Electrons from the battery will go into one end of the wire. When that end gets crowded, the electrons will begin to flow to the other end of the wire and back into the battery. That is a moving current of electrons, an electric current. You can see that the electrons will flow best when the molecules are all in neat rows. Think how hard it would be for you to ride your bike in that parking lot if the cars were parked in all directions instead of neat rows.

Two other things affect how well electricity will flow through metals. The heat of the metal and a magnet nearby will affect electric current.

If a metal is hot, its molecules will move back and forth. When this happens, electrons sometimes crash into the molecules and current is reduced. Think how hard it would be to ride in the parking lot if all the cars began to move back and forth.

A magnet can also make current flow less. The force of a magnet will push the electrons to the opposite side of the wire. The result would be like a strong wind pushing you and all your friends to one side of the parking lot. The electrons, like you, would have to slow down and all try to move along the same path. So current would be less.

NAME _____

Each question has only one correct answer. Circle the letter of the choice that best answers the question.

1. Electrical current flows easily through Substance X. Substance X is:
 - a. not a conductor of electricity
 - b. a good conductor of electricity
 - c. a bad conductor of electricity
 - d. a good conductor of heat
 - e. a bad conductor of heat
2. Electrons
 - a. can be made to move.
 - b. are always connected to atoms.
 - c. are always inside molecules.
 - d. cannot move from their positions.
3. Metals are
 - a. the best conductors of electricity
 - b. good, but not the best, conductors of electricity
 - c. bad conductors of electricity
 - d. not conductors at all
4. Good conductors of electricity have
 - a. many molecules
 - b. few molecules
 - c. many free electrons
 - d. few free electrons
5. Electric current is
 - a. a stationary force
 - b. a transfer of motion
 - c. a flow of electrons
 - d. a flow of molecules
6. Particles that can move anywhere in the structure of metals are called
 - a. free molecules
 - b. free atoms
 - c. free electrons
 - d. none of the above
7. Free electrons can be produced by
 - a. a battery
 - b. metal molecules
 - c. atoms
 - d. other electrons

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8. What happens when you connect a metal wire to a battery?
- molecules flow from the battery into the wire.
 - molecules flow from the wire into the battery.
 - electrons flow from the battery onto the wire.
 - the wire gets hot.
9. An electric current flows when
- the wire is in a certain position.
 - electrons and molecules vibrate.
 - electrons crash into molecules.
 - there are too many electrons crowding into one end of the wire.
10. When does an electric current flow best?
- when the molecules vibrate
 - when the electrons are in neat rows
 - when the molecules are in neat rows
 - when the electrons stand still
11. How many things affect the flow of electricity?
- one
 - two
 - three
 - none
12. Which of these will decrease current flow?
- the heat of the metal and a magnet nearby
 - the kind of metal and impurities in the metal
 - pressure on the metal and the heat of the metal
 - only impurities in the metal
 - only the heat of the metal
13. If the metal molecules vibrate, then electric current will be
- increased
 - reduced
 - unchanged
 - first increased, then reduced
 - first reduced, then increased
14. If a metal is hot, then
- electrons will move more easily
 - electrons will move more slowly
 - electrons will crash into molecules more often
 - none of the above
15. What will a nearby magnet do to current flow?
- increase it
 - decrease it
 - not affect it
 - decrease it, then increase it
 - increase it, then decrease it

Most people use the terms "temperature" and "heat" as though they mean the same thing. But our senses cannot detect heat. What we do detect is a change in temperature. We will be talking about how heat is transferred from one location to another in a substance which is metallic in nature. This transfer is called conduction.

Heat transfer is best thought of as a transfer of motion. In conduction, this transfer occurs through a solid substance, like metal. Suppose we could look inside of a metal bar. We would see that the molecules are bonded together in an orderly way. This group of molecules, all in order, is surrounded by many "free-floating" electrons. The electrons are not attached to any molecules. They are free to move anywhere around the molecules.

Heat energy comes from the separate motion of the molecules.

The molecules vibrate back and forth. So in metal, which is a good conductor of heat, the electrons and molecules are all moving. Temperature tells us something about the speed of the moving molecules. In any substance, the more heat energy it gets, the more rapidly the molecules move.

What happens if one end of a metal bar is heated? The free electrons near the heat begin to move faster. They bump into other free electrons and molecules. These particles then begin to move faster. Then the electrons that were hit bump into more particles, which move more rapidly. The molecules near the heat also increase in speed. They cause the molecules connected to them to move faster, which make the next ones in the line move faster, and so on. Soon, all the electrons and molecules are vibrating more rapidly.

Thus, heat has been transmitted through the whole length of the bar. The temperature of the whole bar is now higher.

Two things affect the flow of heat in metal. They are pressure and impurities in the metal. If pressure is applied to the metal bar, heat flow is less efficient. Pressure changes the structure of the molecules that are connected together. This disturbs the vibration of the molecules. Also, the electrons will not be able to bump into other particles in a straight line. Heat flow will be reduced.

An impurity in the metal will also cause less efficient heat transfer. An impurity will push the molecules out of line and stand in the way of heat flow. The heat energy will be blocked when it reaches the impurity.

NAME _____

Each question has only one correct answer. Circle the letter of the choice that best answers the question.

1. How is heat transmitted through the whole metal bar?
 - a. The electrons travel from one end of the bar to the other.
 - b. The molecules travel from one end of the bar to the other.
 - c. The vibration of the electrons and molecules travels from one end of the bar to the other.
 - d. The electrons are attracted by one end of the bar.
2. The molecules inside a bar of metal
 - a. cannot vibrate
 - b. can vibrate only back and forth
 - c. can vibrate in circular directions
 - d. can vibrate in any direction
3. When one end of a metal bar is heated, what happens?
 - a. Electrons near the heat bump into electrons away from the heat.
 - b. Electrons away from the heat bump into electrons near the heat.
 - c. Electrons will stop bumping into each other.
 - d. Nothing happens to the electrons. The molecules bump into each other.
4. The molecules in a bar of metal
 - a. are bonded together in circular shapes.
 - b. are bonded together in an orderly way.
 - c. are not attached to each other.
 - d. can move anywhere.
5. Heat transfer through solid substances is called
 - a. transference
 - b. convection
 - c. conduction
 - d. radiation
6. Free-floating electrons
 - a. stay in one place. They cannot move.
 - b. are repelled by the metal molecules.
 - c. can move in one direction around a particular molecule.
 - d. can move in any direction.
7. Our senses detect
 - a. changes in heat
 - b. changes in temperature
 - c. changes in heat and changes in temperature
 - d. neither changes in heat nor changes in temperature

3. Metals are
- not conductors of heat
 - poor conductors of heat
 - good conductors of heat
 - the best conductors of heat
9. When a substance gets more heat energy, the molecules and electrons
- move very rapidly
 - move very slowly
 - stop moving
 - move at a moderate speed
10. The words "heat" and "temperature"
- have the same meaning
 - have opposite meanings
 - are used as if they had the same meanings
 - are used as if they had opposite meanings
11. The flow of heat can be slowed down from
- the presence of a nearby magnet and pressure on the bar
 - the heat of a bar and a nearby magnet
 - pressure on and impurities in the bar
 - only impurities in the bar
 - only the presence of a nearby magnet
12. In reality, heat transfer is a transfer of
- motion
 - molecules
 - electrons
 - temperature
13. What will an impurity in metal do?
- It will cause more collisions between electrons and molecules.
 - It will cause crowding of the electrons.
 - It will block heat energy that reaches it.
 - It will help to transmit the movement of molecules to other particles.
14. How many things affect heat flow in metals?
- one
 - two
 - three
 - none
15. What does applying pressure to metal do to heat flow?
- Electrons cannot hit other particles in a straight line.
 - Electrons will bump into other particles in a straight line.
 - Heat flow will be faster.
 - Heat flow will not be affected.

Most people use the words "temperature" and "heat" as though they had the same meaning. But we can not see, feel, hear, taste, or smell heat. What we can see and feel is a change in temperature. We will be talking about how heat is transferred from one place to another in metal. This transfer is called conduction.

Heat transfer is really a transfer of motion. In conduction, this transfer of motion is through a solid substance like metal. Suppose we could look at the inside of a metal bar. We would see the molecules joined together to form little boxes. The boxes have open sides. Think of building boxes out of tinker-toys. The solid round parts that you put the sticks in would be like the molecules. The molecules form the corners of the boxes. These boxes have free electrons around them. The electrons are not attached to any molecules. They can move anywhere. You can picture this by pretending that a lot of flies are flying through your tinker-toy boxes.

In our bar of metal, which is a good conductor of heat, the molecules and electrons are all moving. The molecules can only move back and forth because they are all hooked together. The molecules move at a certain speed. This speed tells us the temperature of the bar. When the temperature is high, the molecules and electrons move very fast.

What if we heat one end of the metal bar? The free electrons and molecules near the heat will move faster. The electrons will bump into other electrons further away from the heat. The boxes of molecules will vibrate faster. This will cause other boxes connected to them to move faster. Soon, all the electrons and boxes of molecules will be moving faster. Then the whole bar will feel hotter. This transfer is like pushing over a row of dominos. When you push the first one over, that will push the next one, and so on.

Two things affect the flow of heat in metal. They are pressure and impurities in the metal. If we apply pressure to the bar, the flow of heat is slowed down. Pressure changes the shape of the boxes of molecules. This is like putting our dominos in a crooked line. When we push one over, this toppling motion will not be transmitted to all the dominos. Some will stay standing.

An impurity in a metal will also cause less heat to flow. Pretend we put a book in our row of dominos. We would see that the book would stop some dominos from being pushed over. In this way, an impurity in metal will hinder heat flow. It prevents the movement of the molecules and electrons from being transmitted to other molecules and electrons.

Each question has only one correct answer. Circle the letter of the choice that best answers the question.

1. How is heat transmitted through the whole metal bar?
 - a. The electrons travel from one end of the bar to the other.
 - b. The molecules travel from one end of the bar to the other.
 - c. The movement of the electrons and molecules travels from one end to the other.
 - d. The electrons are attracted by one end of the bar.
2. The molecules inside a bar of metal
 - a. are joined together in circular shapes
 - b. are joined together in box-like shapes
 - c. are not attached to each other
 - d. can move anywhere
3. When we heat one end of a metal bar, what happens?
 - a. Electrons near the heat bump into electrons away from the heat.
 - b. Electrons away from the heat bump into electrons near the heat.
 - c. Electrons will stop bumping into each other.
 - d. Nothing happens to the electrons. The molecules bump into each other.
4. The molecules in a bar of metal
 - a. cannot move
 - b. can move only back and forth
 - c. can move only in circular directions.
 - d. can move in any direction.
5. Heat transfer through solid substances is called
 - a. transference
 - b. convection
 - c. conduction
 - d. radiation
6. Free electrons
 - a. stay in one place. They cannot move.
 - b. are repelled by the metal molecules.
 - c. can move in one direction around a particular molecule.
 - d. can move in any direction.
7. We can feel
 - a. changes in heat
 - b. changes in temperature
 - c. changes in heat and changes in temperature
 - d. neither changes in heat nor changes in temperature

8. Metals are
- not conductors of heat
 - poor conductors of heat
 - good conductors of heat
 - the best conductors of heat
9. When the temperature of a metal bar is high, the molecules and electrons
- move very fast
 - move very slowly
 - stop moving
 - move at a moderate speed
10. The words "heat" and "temperature"
- have the same meaning.
 - have opposite meanings.
 - are used as if they had the same meaning.
 - are used as if they had opposite meanings.
11. The flow of heat can be slowed down from
- the presence of a nearby magnet and pressure on the bar.
 - the heat of the bar and a nearby magnet.
 - pressure on and impurities in the bar.
 - only impurities in the bar
 - only the presence of a nearby magnet.
12. In reality, heat transfer is a transfer of
- motion
 - molecules
 - electrons
 - temperature
13. What will an impurity in metal do?
- It will cause a change in the structure of the molecules.
 - It will cause crowding of the electrons.
 - It will help transmit the movement of the molecules to other particles.
 - It will prevent the movement of molecules from being transmitted to other particles.
14. How many things affect heat flow in metals?
- one
 - two
 - three
 - none
15. What does applying pressure to metal do to heat flow?
- Heat cannot be transmitted in a straight line.
 - Heat will be transmitted in a straight line.
 - Heat flow will be faster.
 - Heat flow will not be affected.

Plants that make seeds in cones are called conifers.

Botanists believe that conifers lived on earth long before flowering plants. They think that plants with flowers developed from conifers.

Conifers do not have flowers with flower parts. Their seeds are not enclosed inside ovaries. They are exposed in cones.

Most conifers have two kinds of cones. In one kind of cone, pollen is formed. Wind carries the pollen from this kind to another larger kind of cone. In the larger cone ovules grow. This cone is turned upward when it is young. When the pollen meets the ovules, seeds are formed.

When the seeds are ripe, the upward growing cone turns down. The seeds drop from the cone and fall to the ground.

In what way is seed making in conifers the same as in flowering plants? In what way is it different?

Most conifers are trees or shrubs, with stems, roots, and leaves. Their leaves are needle-shaped and stay green all year round. They are called evergreens.

Pine, spruce, and fir trees are conifers. Most of our lumber comes from these trees.

Plants that make seeds are one group. The second big group of plants are all those that do not make seeds.

There are many, many different plants in this group. Some of them look very much like seed-making plants. Some do not. Some have leaves, roots, and stems. Some do not. Some are green; some are not.

Ferns and their relatives look very much like seed-making plants.

They are green, and have roots, stems, and leaves. They have a transportation system of tubes which runs through these parts, carrying water, food, and minerals.

However, ferns do not make seeds. Ferns grow from spores. Spores do not have a baby plant in them.

A fern's leaves are called fronds. If you examine the underside of some ferns, you may find tiny dots. Each of these dots contains many spores.

Spores can grow into special kinds of plants. These do not look like ferns. But they produce two special kinds of cells. One kind of cell has to swim over to the other one. When these two cells meet, a new fern plant is begun.

Scientists guess that ancient, fern-like plants gave rise to seed-making plants. Scientists have found fossil plants like these. They believe that conifers developed from these spore-makers.

APPENDIX B: Raw Data

1. Criterion test scores
2. Percent correct idea units
3. Reading comprehension scores

<u>Condition</u>	<u>S #</u>	<u>Criterion Test Score</u>	<u>% correct Idea Units</u>	<u>Reading Comprehension Grade Equivalency</u>
Control-EA	1	5	36.7	-
	2	4	23.3	2.9
	3	14	96.7	8.2
	4	11	73.3	8.8
	5	13	90.0	9.5
	6	12	80.0	4.3
	7	5	30.0	5.2
	8	4	20.0	6.0
	9	5	30.0	3.7
	10	3	23.3	4.2
Cont.-EC	11	11	65.4	6.5
	12	0	0	4.1
	13	2	11.5	5.0
	14	4	26.9	-
	15	12	73.1	4.9
	16	12	88.5	-
	17	13	84.6	9.5
	18	11	76.9	7.0
	19	8	53.8	5.1
	20	12	76.9	-
Cont.-HA	21	4	17.1	3.9
	22	7	57.1	4.4
	23	13	91.4	8.2
	24	9	60.0	3.6
	25	7	57.1	5.8
	26	3	40.0	-
	27	6	48.6	5.2
	28	5	25.7	4.0
	29	4	37.1	3.3
	30	8	45.7	3.6
Cont.-HC	31	7	43.3	4.0
	32	6	40.0	1.9
	33	5	43.3	10.5
	34	10	80.0	5.3
	35	7	40.0	4.0
	36	11	73.3	5.8
	37	4	26.7	2.3
	38	7	46.7	-
	39	9	73.3	6.8
	40	5	36.7	4.7
Hc-EC	41	7	40.0	6.0
	42	8	53.8	3.9
	43	5	26.9	3.4
	44	7	42.3	5.3
	45	12	73.1	5.6
	46	3	15.4	6.1
	47	5	42.3	5.8
	48	8	42.3	-
	49	4	26.9	4.8
	50	9	46.2	-
	51	5	34.6	5.2
	52	8	50.0	7.0

Condition	S #	Criterion Test Score	% correct Idea Units	Reading Comprehension Grade Equivalency
EC-HC	53	9	70.0	4.3
	54	6	33.3	3.1
	55	5	40.0	4.5
	56	3	23.3	-
	57	10	56.7	4.8
	58	9	63.3	5.2
	59	2	10.0	4.8
	60	10	56.7	6.7
	61	5	23.3	5.9
	62	7	40.0	4.8
HA-EA	63	10	73.3	4.9
	64	8	63.3	4.0
	65	4	23.3	5.3
	66	6	33.3	5.8
	67	4	23.3	5.6
	68	12	83.3	5.8
	69	4	26.7	-
	70	12	83.3	5.9
	71	4	26.7	3.7
	72	6	36.7	6.7
EA-HA	73	5	30.0	5.4
	74	7	40.0	-
	75	9	65.7	-
	76	5	45.7	-
	77	3	17.1	4.9
	78	8	68.6	5.1
	79	8	65.7	5.2
	80	5	25.7	4.3
	81	9	60.0	6.6
	82	7	57.1	5.3
HC-EA	83	9	48.6	5.8
	84	7	60.0	4.5
	85	6	33.3	6.0
	86	4	20.0	5.2
	87	8	53.3	5.3
	88	8	46.7	10.5
	89	4	36.7	2.3
	90	12	80.0	5.9
	91	7	46.7	3.6
	92	5	23.3	3.3
EC-HA	93	6	40.0	4.1
	94	8	40.0	5.8
	95	4	30.0	3.3
	96	5	23.3	4.9
	97	5	22.9	3.0
	98	7	37.1	4.4
	99	7	37.1	3.4
	100	5	22.9	5.7
	101	5	34.3	5.4
	102	11	62.9	9.5
	103	9	68.6	5.2
	104	4	40.0	5.3
	105	8	45.7	7.2
	106	12	65.7	6.8
	107	7	37.1	3.9
	108	6	53.3	5.9

<u>Condition</u>	<u>S #</u>	<u>Criterion Test Score</u>	<u>% correct Idea Units</u>	<u>Reading Comprehension Grade Equivalency</u>
EA-HC	109	10	70.0	5.6
	110	8	56.7	-
	111	4	26.7	-
	112	5	23.3	6.8
	113	10	76.7	4.9
	114	9	60.0	5.8
	115	3	20.0	4.1
	116	9	60.0	5.1
	117	14	93.3	6.5
	118	9	73.3	6.6
	119	5	30.0	5.5
	120	4	15.4	v-
	121	1	3.8	2.6
	122	6	42.3	2.8
HA-EC	123	9	42.3	10.5
	124	5	34.6	4.7
	125	5	38.5	5.5
	126	9	61.5	4.6
	127	5	26.9	4.1
	128	9	69.2	5.6
	129	5	30.8	6.5
	130	6	34.6	5.8

APPENDIX C: Distribution of Errors
on Criterion Test Questions

Question	Total		Control		EC		EA		(Passage 1)
	HA	HC	HA	HC	HA	HC	HA	HC	(Passage 2)
1.	a)	7	7	1	4	4	2	2	
	b)	6	9	2	3	4	1	1	
	c)	17	13	7	3	3	7	6	
	d)	3	2	0	2	0	1	1	
2.	a)	3	2	2	0	1	1	1	
	b)	18	23	4	9	7	5	8	
	c)	0	2	0	0	1	0	1	
	d)	12	4	4	3	2	5	0	
3.	a)	22	15	4	9	4	9	5	
	b)	4	5	3	1	2	0	2	
	c)	2	3	1	1	1	0	0	
	d)	5	7	2	1	4	2	2	
4.	a)	9	1	3	0	0	4	1	
	b)	18	21	4	8	9	6	6	
	c)	4	2	2	2	1	0	1	
	d)	2	7	1	0	1	1	2	
5.	a)	14	9	6	3	4	4	2	
	b)	3	0	1	0	0	1	0	
	c)	13	17	3	6	5	4	6	
	d)	3	5	0	1	2	2	2	
6.	a)	0	2	0	0	0	0	0	
	b)	3	3	1	1	2	1	0	
	c)	14	5	5	7	4	2	0	
	d)	16	21	4	4	5	8	10	
7.	a)	3	6	1	2	1	1	3	
	b)	19	12	6	7	5	6	5	
	c)	8	11	3	5	5	4	1	
	d)	3	2	0	3	0	0	1	
8.	a)	4	1	2	0	0	1	1	
	b)	2	1	0	0	1	2	0	
	c)	18	21	5	6	6	7	6	
	d)	9	8	3	5	4	1	3	
9.	a)	26	20	8	9	6	9	7	
	b)	2	6	0	1	3	1	2	
	c)	0	1	0	0	0	0	0	
	d)	5	4	2	2	2	1	1	
10.	a)	6	8	2	3	2	3	3	
	b)	4	2	0	0	1	2	1	
	c)	20	16	6	8	4	6	6	
	d)	3	5	2	1	4	0	0	
11.	a)	9	8	3	2	2	4	3	
	b)	4	3	1	1	1	2	1	
	c)	8	10	3	3	4	2	3	
	d)	1	5	1	0	1	0	2	
	e)	11	5	2	6	3	3	1	
12.	a)	6	6	3	0	5	1	1	
	b)	12	4	3	5	1	4	2	
	c)	9	7	2	4	1	3	4	
	d)	6	14	2	1	4	3	3	
13.	a)	7	10	2	2	4	3	3	
	b)	6	8	2	2	2	2	3	
	c)	9	5	4	4	3	1	1	
	d)	11	8	2	4	2	5	3	

14.	a)	8	5	4	2	2	3	2	0
	b)	12	17	4	4	4	7	4	6
	c)	11	4	2	2	5	1	4	1
	d)	2	5	0	2	1	0	1	3
15.	a)	6	9	1	3	3	4	2	2
	b)	13	5	5	2	4	0	4	3
	c)	9	11	1	3	4	4	4	4
	d)	5	6	3	2	1	3	1	1

Question	Total		Control		HC		HA		(Passage 1)
	EA	EC	EA	EC	EA	EC	EA	EC	(Passage 2)
1.	a)	2	2	0	0	1	2	1	0
	b)	24	22	8	8	10	8	6	6
	c)	2	2	1	1	1	0	0	1
	d)	3	6	1	1	0	1	2	4
	e)	1	0	0	0	1	0	0	0
2.	a)	24	20	8	8	10	6	6	6
	b)	4	4	0	1	1	0	3	3
	c)	1	4	0	0	1	2	0	2
	d)	3	4	2	1	1	3	0	0
3.	a)	2	18	0	5	1	7	1	6
	b)	5	9	1	4	2	3	2	2
	c)	16	2	6	1	7	1	3	0
	d)	9	3	3	0	3	0	3	3
4.	a)	16	12	6	3	4	6	6	3
	b)	10	1	3	0	5	0	2	1
	c)	2	15	1	6	1	4	0	5
	d)	4	4	0	1	3	1	1	2
5.	a)	13	1	4	0	6	0	3	1
	b)	2	6	2	2	0	2	0	2
	c)	14	16	4	6	5	6	5	4
	d)	3	9	0	2	2	3	1	4
6.	a)	6	9	2	0	3	4	1	5
	b)	14	8	7	4	3	2	4	2
	c)	5	13	0	5	4	4	1	4
	d)	7	2	1	1	3	1	3	0
7.	a)	20	19	5	6	9	7	6	6
	b)	4	6	2	2	0	3	2	1
	c)	1	3	0	1	1	1	0	1
	d)	7	3	3	1	3	0	1	2
8.	a)	10	15	3	4	5	8	2	3
	b)	3	8	0	2	0	1	3	5
	c)	13	7	5	4	7	1	1	2
	d)	6	2	2	0	1	1	3	1
9.	a)	3	4	0	0	2	2	1	2
	b)	10	16	2	3	6	6	2	7
	c)	3	2	2	1	1	0	0	1
	d)	16	10	6	6	4	3	6	1
10.	a)	14	5	3	2	7	2	4	1
	b)	10	8	5	2	2	4	3	2
	c)	6	16	2	6	3	4	1	6
	d)	2	3	0	0	1	1	1	2
11.	a)	7	3	2	0	2	1	3	2
	b)	11	13	3	3	5	6	3	4
	c)	13	15	5	6	5	4	3	5
	d)	0	1	0	1	0	0	0	0
12.	a)	11	17	2	7	5	7	4	3
	b)	11	4	4	0	5	1	2	3
	c)	5	6	2	1	3	3	0	2
	d)	1	2	0	1	0	0	1	1
	e)	4	3	2	1	0	0	2	2
13.	a)	18	15	2	3	9	8	7	4
	b)	7	12	4	5	2	3	1	4
	c)	2	3	2	1	0	0	0	2
	d)	2	1	2	1	0	0	0	0
	e)	2	1	0	0	1	0	1	1

14.	a)	11	11	5	4	2	3	4	4
	b)	10	5	4	2	2	3	4	0
	c)	3	9	0	4	3	1	0	4
	d)	8	7	1	0	6	4	1	3
15.	a)	14	5	6	1	4	2	5	2
	b)	4	16	0	6	2	6	2	3
	c)	11	6	2	1	7	1	2	4
	d)	2	1	2	1	0	0	0	0
	e)		4		1		1		2

